

AME 598i
Prof. J. M. Powers
Homework 7
Due: Friday, 21 March 2003

1. Consider a slab of the solid energetic material LX-14 (a common explosive). The slab has length $L = 0.25 \text{ m}$. Assume the LX-14 has material properties as given by Powers¹, with the following exceptions, which we take to avoid problems of numerical convergence, $a = 5 \times 10^{-5} \text{ s}^{-1}$, $E = 2.206 \times 10^4 \text{ J/mol}$. Solve the Frank-Kamenetskii problem for this scenario. Assume the temperature at the outer radius is held fixed at 300 K and the temperature evolution is governed by the following differential equation as developed in lecture:

$$\frac{\partial T}{\partial t} = \frac{1}{D} \frac{\partial}{\partial x} \left(\frac{\partial T}{\partial x} \right) + (1 - T) \exp \left(\frac{-\Theta}{1 + QT} \right).$$

- (a) Use a numerical shooting technique to solve for the temperature distribution $T(x)$ in the limit of steady state.
- (b) Use a two term collocation technique to estimate the temperature distribution $T(x)$. Compare with your result from the shooting technique.
- (c) Holding other parameters fixed, vary D and plot $T(x = 0)$ as a function of D .
- (d) Find the critical slab length below which small temperature solutions may exist.

¹Powers, J. M., 1999, "Thermal explosion theory for shear localizing energetic solids," *Combustion Theory and Modelling*, Vol. 3, pp. 103-122.